SUBSTITUTE SPECIFICATION

METHOD AND INJECTION MOLD FOR MAKING A COMPOSITE INJECTION MOLDED PRODUCT

TECHNICAL FIELD

The present invention relates to a method of forming a composite injection molding having primary and secondary resin molding products and to an injection mold, as well as to the resulting composite injection molded product. More particularly, the invention relates to a composite injection molding method wherein portions at which the secondary resin molding product is united with the primary resin molding product with poor adhesion are compressed selectively and locally.

BACKGROUND ART

Conventionally, a composite injection molding product has been molded such that a primary resin molding product is injection-molded, and a secondary resin is injected onto the primary resin molding. Known methods of composite injection molding include two-color molding processes such as a rotary process, a core bag process, and a slide process.

In composite injection molding, ensuring adhesion and air tightness of the secondary resin molding product to the primary resin molding product is a very important technical point in terms of prevention of breakage that could initiate from an interface when pressure is applied to the inside of a composite injection molding product, as well as in terms of prevention of entry of water into the composite injection molding product from the outside.

Conventionally, techniques for ensuring adhesion and air tightness of the secondary resin molding product to the primary resin molding product have been studied in relation to (a) resin material to be molded and (b) molding apparatus and molding method.

According to a known method in relation to (a), a primary resin of a melting point lower than that of a secondary resin is used, whereby the primary resin is melted upon contact with the injected secondary resin.

According to a disclosed technique in relation to (b), an entire region that is expected to be subjected to adhesion or fusion is pressed or compressed by use of a mold mechanism (see, for example, Japanese Patent Application Laid-Open (*kokai*) No. 7-290500 (claim 1, FIG. 1) and Japanese Patent Application Laid-Open (*kokai*) No. 9-11344 (claim 1, FIG. 3)).

However, in the case of a composite injection molding product of a certain shape, these techniques have failed to impart sufficient adhesion.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide a composite injection molding product in which a primary resin molding product and a secondary resin molding product attain improved adhesion and air tightness.

According to embodiments of the present invention, a composite injection molding product exhibiting improved adhesion and air tightness are provided. Specifically, it has been found that adhesion and air tightness of the composite injection molding product can be efficiently improved when, in the course of composite injection molding, vicinities of locations where adhesion is poor—such as a portion located a long distance from a secondary resin gate, and portions, such as bosses and ribs, projecting from the surface of a secondary resin molding product—are locally compressed by use of an ejector mechanism of an injection molding machine or a mechanism provided on a mold for moving a portion of the mold by means of fluid pressure, electrical drive, or repulsion force of an elastic member such as a spring.

Accordingly, one aspect f the present invention provides a method of composite injection molding for shaping a composite injection molding product by forming, through

injection, a secondary resin molding product onto a primary resin molding product, which comprises applying a compression pressure on a secondary resin molding product side, to thereby improve adhesion between the primary resin molding product and the secondary resin molding product and air tightness therebetween, characterized in that portions at which the secondary resin molding product is united with the primary resin molding product (with poor adhesion are compressed selectively and locally. According to another embodiment of the present invention, the secondary resin molding product has projecting portions projecting outwardly, and the projecting portions are compressed locally.

According to yet another aspect of the present invention, the projecting portions are bosses or ribs.

Certain embodiments of the present invention will include locally compressing that portion of the secondary resin molding product which is located a long distance from the secondary resin gate.

Certain other embodiments of the invention will provide for a starting time of pressing which is within the elapse of 20 seconds of surface hardening time after gate sealing time of the secondary resin.

Injection molds used for the method of composite injection molding as described herein will preferably include a local pressing means for selectively and locally compressing portions at which the secondary resin molding product is united with the primary resin molding product with poor adhesion.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. 1a and 1b are front and side elevational views, respectively, of a primary resin molding product according to examples and a comparative example.

FIGS. 2a and 2b are front and side elevational views, respectively ofa composite injection molding product according to examples and a comparative example.

FIG. 3 is a front elevational view of a composite injection molding product according to Example 1 or 2 as viewed from the secondary resin molding product side.

FIG. 4 is a view showing the state of adhesion, as observed on an ultrasonic analyzer, of a conventional composite injection molding product involving a long distance of flow.

FIG. 5 is a view showing the state of adhesion, as observed on an ultrasonic analyzer, of a conventional composite injection molding product having projecting portions.

BEST MODE FOR CARRYING OUT THE INVENTION

In composite injection molding, an important point for maintaining good adhesion of a secondary resin molding product to a primary resin molding product is to melt the uppermost surface of a hardened primary resin by means of the heat associated with the molten secondary resin so as to establish sufficient fusion between the primary resin molding product and the secondary resin molding product.

Another important point is that the interface between the primary resin and the secondary resin must be free from fusion fracture or separation which could result from contraction or expansion of the resins in the course of transition of the resins from a molten state to a hardened state.

The present invention is characterized in that, in order to carry out effective and sufficient compression, pressure is locally applied in accordance with the local hardening condition of the secondary resin and that, in order to carry out more effective application of pressure, portions corresponding to ribs and bosses, which encounter difficulty in hardening of molten resin, are locally compressed.

A method of composite injection molding and a composite injection mold according to the present invention will be described hereinafter with reference to the drawings.

FIGS. 1a and 1b are front and side elevational views, respectively, of a primary resin molding product 1 to which a secondary resin molding product 2 is to be molded so

as to form a composite injection molding product 10 (see FIGS. 2a and 2b). The primary resin molding product 1 is formed by injecting molten resin through the primary gate 9 of a mold (not shown) and then allowing the product 1 to solidify therein. As shown in FIGS. 2a and 2b, the composite injection molding product 10 is shown as viewed from the side of the secondary resin molding product 2. The secondary resin molding product 2 is thus formed on the primary resin molding product 1 by injecting a secondary resin from a secondary resin gate (not shown) through an aperture 17 formed in the primary molding product 1 so as to fill the mold and thereby yield the composite injection molding product 10. As can be seen in FIG. 3, a portion 8 in the form of a projecting rib is located a relatively long distance of flow from the secondary resin gate 7 and thus represents a rejection against which local pressing is accomplished. The projecting rib 5 extending outwardly from the primary resin molding product 1 is used to measure adhesion strength between the primary and secondary resin molding products 1, 2, respectively.

According to the present invention, it has been found that a portion located a long distance of flow from a secondary resin gate position involves the problem noted below. Specifically, the problem encountered in such a situation is that, during the course of flow of a molten secondary resin over a long distance, the mold gradually removes heat from the molten secondary resin, and thus the molten secondary resin may not have sufficient heat so as to adequately melt the primary resin. Also, as hardening of the molten secondary resin progresses in the vicinity of the resin gate, propagation of pressure for pressing the primary and secondary resins against each other declines, and thus fusional adhesion retards. Even when the melting is carried out, subsequent contraction occurs to a great extent, thereby causing occurrence of fusion fracture or separation. As a result, sufficient adhesion cannot be obtained.

Basically, in order to apply pressure to a secondary resin molding product, pressing must be started before the secondary resin is completely hardened. In actual composite injection molding, hardening starts from the stage where a molten resin flows and comes

into contact with a mold. Thus, from the initial stage of flow of the molten resin, hardening progresses in the vicinity of the resin gate. At the stage where the molten resin reaches a near end destination of flow, which corresponds to a near distal end of the secondary molding product, hardening progresses to a certain extent in the vicinity of the resin gate. Therefore, application of pressure on the whole body of a composite injection molding product encounters difficulty in achieving ensured adhesion and air tightness. When pressing is carried out while the resin fails to reach the end destination of flow, a corresponding region that is not filled with resin is not pressed; thus, pressing fails to yield the expected effect.

In a case involving a long distance of flow from the secondary resin gate position or involving portions, such as bosses and ribs, projecting outwardly from the surface of a composite injection molding product, conventional composite injection molding tends to be inferior in adhesion of the secondary resin molding product to the primary resin product as measured at positions corresponding to such portions.

FIG. 4 shows the state of adhesion of the secondary resin molding product to the primary resin molding product as observed on an ultrasonic analyzer, in the case of a composite injection molding product involving a long distance of flow from the secondary resin gate position. FIG. 5 shows the state of adhesion of the secondary resin molding product to the primary resin molding product as observed on the ultrasonic analyzer, in the case of a composite injection molding product having portions, such as bosses and ribs, projecting from its surface. A portion 21 of good adhesion is observed in black. Portions 22 of inferior adhesion are observed in gradations ranging from white (represented by w) to red (represented by r). The analysis results reveal that adhesion is impaired with the distance of flow and that projecting portions are inferior in adhesion.

Therefore, according to the present invention, a portion 8 located in a long distance of flow from the secondary resin gate position is locally compressed.

One or more portions to be pressed locally may be provided

A "position located in a long distance of flow from the secondary resin gate" means that the position is located such that the ratio between the distance to the position from the secondary resin gate and the thickness d of a molding product (L/d) is 20 or more. No upper limit is imposed on the ratio, so long as short shot does not occur. When the ratio is less than 20, pressing fails to yield a marked effect.

One or more portions to be compressed may be provided. No particular limitation is imposed on the area of the portion to be compressed. However, because of limitations associated with a drive mechanism, an excessively large area reduces a pressing force, thereby leading to difficulty in yielding the effect of pressing.

Preferably, a pressing force is equal to or greater than a dwell pressure applied to resin. Preferably, a pressing volume is near a contraction volume of the secondary resin.

Preferably, the starting time of pressing is within elapse of 20 seconds of gate hardening time (usually, substantially equal to surface hardening time of resin filled into the mold) after injection of the secondary resin; i.e., pressing is started within the period of time. If pressing is started before the starting time of pressing, a pressing force escapes from the unhardened gate and fails to be sufficiently applied to the resin. If pressing is started after the starting time of pressing, the resin surface is hardened excessively, and thus the effect of pressing is not sufficiently yielded.

FIG. 3 is a plan view of the composite injection molding product 10 as viewed from the secondary resin molding product 2 side, which is formed on the primary resin molding product 1 by injecting the secondary resin 12 from the secondary resin gate 7 in a mold filling manner to thereby yield the composite injection molding product 10. In FIG. 3, regions A and C and a region B corresponding to rib 8 located a long distance of flow from the secondary resin gate 7 are the portions that may be pressed. In addition, the rib 8 may also serve as a rib used to measure adhesion strength.

Projecting portions, such as ribs 8 (also known as bosses), projecting from the surface of the secondary molding product are prone to involve fusion fracture or separation

after fusion of primary and secondary resins subsequent to remelting of the primary resin as mentioned above and thus tend to involve a drop in adhesion.

Specifically, the projecting portions of ribs 8 projecting outwardly from the composite injection molding product are portions, such as bosses and ribs, projecting from the surface of the secondary molding product. Thus, a surface-depressing phenomenon called a sink mark arises on the interface between the primary resin and the secondary resin at positions located behind the bosses and ribs. As a result, fusion fracture or separation is prone to occur on the interface between the primary and secondary resins. Additionally, flow of the molten resin into mold cavities corresponding to bosses and ribs causes resin orientation to differ from that in a region where the secondary resin flows in a planar manner. Thus, linear expansion varies locally, also leading to fusion fracture or separation on the interface between the primary and secondary resins.

Preferably, in order to carry out effective pressing, portions to be compressed are mounded portions, such as the ribs (bosses) 8, of a molding product. Formation of a mound on a molding product yields the effect of increasing the thickness of the molding product, whereby internal hardening of molten resin is slowed down. Thus, pressing can be controlled under a wider range of pressing conditions, thereby allowing effective pressing.

One or more portions to be pressed may be provided. Thus pressure may be applied locally at a plurality of positions.

The projecting portions (e.g., ribs 8) preferably have a height of 0.5 mm or more.

In the case where a plurality of portions of inferior adhesion are to be potentially formed, the starting time of pressing is locally adjusted according to the local hardening condition of the molten secondary resin, whereby high adhesion can be obtained.

A mold for use in composite injection resin molding according to the present invention is adapted to mold a composite injection molding product by injecting the secondary resin injection molding product 2 onto the primary resin molding product 1 and

to compress selectively and locally, from the secondary resin molding product side, portions at which the secondary resin molding product 2 is united with the primary resin molding product 1 with poor adhesion.

A local pressing means 6 may be a means that utilizes an ejector mechanism of an injection molding machine; for example, an ejector pin, or a means for performing pressing within a mold by means of a movable core that is driven oil-hydraulically, pneumatically, or by spring force.

Resins usable in the present invention are thermoplastic resins. Usable types of thermoplastic resin include crystalline resin, noncrystalline resin, biodegradable resin, nonbiodegradable resin, synthetic resin, natural resin, general-purpose resin, engineering resin, and polymer alloy.

Examples of thermoplastic resin include polyethylene (PE), polypropylene (PP), polystyrene (PS), AS resin, ABS resin, polyvinyl chloride (PVC), polyacrylonitrile (PAN), (meth)acrylic resin, cellulose resin, polyurethane, and elastomer.

Examples of engineering resin include aliphatic polyamides such as nylon 6, nylon 6,6, nylon 12, and nylon 6,12; aromatic polyamides (PA); aromatic polyester resins (such as polyethylene terephthalate (PET) and polybutylene terephthalate (PBT)); polycarbonates (PC); polyacetal; polyphenylene ether (PPO); polyphenylene sulfide (PPS); liquid crystalline polymers such as liquid crystalline polyester and liquid crystalline polyamide; and fluorine-containing resin.

Usable biodegradable resins include aliphatic polyesters derived from aliphatic dicarboxylic acid, aliphatic diol, aliphatic hydroxycarboxylic acid, or aliphatic polyester derived from a cyclic compound thereof, and aliphatic polyesters which are derived therefrom by increasing their molecular weight through linking of diisocyanate or the like.

The primary resin and the secondary resin may be the same resin or different resins. Employment of a working temperature of the secondary resin higher than the hardening temperature of the primary resin enhances adhesion.

The primary and secondary resins may contain various fillers, stabilizers, and modifiers, which are of any shape, such as fibrous, platelike, spherical, and indeterminate, and are either inorganic or organic.

Applications of a composite injection resin molding product according to the present invention include exterior components, such as housings; electric components, such as switches and connectors; mechanism components, such as levers, gears, and cams; and hollow components.

(Examples)

The present invention will be described hereinafter in detail by way of example, which should not be construed as limiting the invention.

(Examples 1 and 2 and Comparative Example 1)

DURANEX 303RA (product of WinTech Polymer Ltd.; low-melting-point-type glass-fiber-containing PBT resin of a melting point of about 205°C) was used as the primary resin, and DURANEX 3300 (product of WinTech Polymer Ltd.; ordinary-type glass-fiber-containing PBT resin of a melting point of about 225°C) was used as the secondary resin.

First, a primary resin molding product as shown in FIG. 1 was molded. The cooled-and-hardened primary resin molding product was cooled to harden and was then placed in the cavity of a mold. The secondary resin was injected onto the primary resin molding product through a pin gate of a diameter of 1.5 mm under the conditions of a cylinder temperature of 270°C and an injection speed of 10 mm/s, whereby the mold of a temperature of 80°C was filled with the secondary resin. Thus, a composite injection molding product as shown in FIG. 2 was obtained.

A product portion of the primary resin molding product measures 130 mm (length) x 40 mm (width) x 3 mm (thickness). A product portion of the secondary resin molding product measures 100 mm (length) x 30 mm (width) x 2 mm (thickness). The area of

adhesion between the primary resin molding product and the secondary resin molding product is 100 mm x 30 mm.

Reference numeral 9 denotes a primary resin gate, and reference numeral 17 denotes a through-hole for a secondary resin gate. Reference numeral 7 denotes the secondary resin gate. Two ribs 5 were provided on the primary resin molding product 1, and two ribs 8 were provided on the secondary resin molding product 2. The ribs 8 provided on the secondary resin molding product are located 10 mm and 70 mm, respectively, away from the secondary resin gate 7. The ribs 5 provided on the primary resin molding product 1 are located behind the corresponding ribs 8 provided on the secondary resin molding product 2.

In Example 1, local pressing was carried out by utilization of the ejector mechanism of an injection molding machine. As shown in FIG. 3, the position of local pressing is position A, which is located a long distance of flow from the secondary resin gate 7. The diameter of a portion to be pressed is 10 mm; pressing force is 3,000 kg; and a pressing stroke varies with time elapsing after injection. At the elapse of 0 second after injection, the cavity is not completely filled with resin, and thus pressing is not carried out.

In Example 2, local pressing was carried out by utilization of the ejector mechanism of the injection molding machine. As shown in FIG. 3, the position of local pressing is position B, at which the far-side rib, distant from the secondary resin gate, of the secondary molding product is located (the gate-side rib is not subjected to local pressing). A portion to be pressed measures 15 mm x 1.5 mm (rectangle); pressing force is 3,000 kg; and a pressing stroke is 0.5 mm.

In Comparative Example 1, the entire surface of adhesion was pressed. Full-surface pressing was carried out in the mold-closing direction at a pressing force of 100 t and a maximum pressing stroke of 0.1 mm.

The starting time of pressing is the starting time of advancing the ejector pin and is represented by seconds as measured after injection.

The ribs of the primary and secondary resin molding products were pulled, and adhesion strength (maximum load) was measured at the position of the far-side ribs.

Table 1 shows measurement results of the starting time of pressing, pressing stroke, and adhesion strength.

In Table 1, EJ Stop1 means surface hardening time in the case of pressing the portion A, and EJ Stop 2 means surface hardening time in the case of pressing the rib B.

Table 2 shows measurement results of adhesion strength in the case where the portions A and C are pressed.

Table 1

Starting time of pressing (position of compression)		Example 1 (portion A distant from secondary gate)		Example 2 (rib B distant from secondary gate)		Compar. Example 1 (full surface)
After injection (sec)		Pressing stroke (mm)	Adhesion strength (N)	Pressing stroke (mm)	Adhesion strength (N)	Adhesion strength (N)
0	-	0.00	1067	0.00	1185	1197
1.5		0.40	1233	0.42	1280	1246
3	gate seal	0.38	1300	0.41	1325	1173
5		0.35	1385	0.39	1538	1194
7.5		0.30	1435	0.34	1638	1221
10	EJ Stop1	0.00	1529	0.15	1749	1237
15	EJ Stop2	0.00	1583	0.00	1937	1203
20		0.00	1590	0.00	1950	1221
25		0.00	1534	0.00	1902	1208
30		0.00	1421	0.00	1856	1183
40		0.00	1299	0.00	1645	1200
160		0.00	1275	0.00	1403	1211

Table 2

		Secondary molding product (2 mm)		Secondary molding product (1 mm)	
		Gate side	Far side from gate	Gate side	Far side from gate
Compression not used		2020	1067	390	192
Compression used (10 seconds)	Portion A compressed	2080	1529	411	304
	Portion C compressed	2152	1205	472	243

As is apparent from the above results, as compared with adhesion strength obtained by pressing the entire adhesion surface as practiced conventionally, local pressing according to the present invention provides enhanced adhesion strength.

In full-surface pressing, even when the starting time of pressing is delayed, the effect of pressing does not emerge for the following reason: delay in the starting time promoted surface hardening, and thus pressing could not be actually carried out. In order to solve such a problem involved in the conventional method, the present invention employs local pressing, which is carried out locally and thus can be readily controlled. Thus, the present invention improves adhesion strength of a molding product.

Even in practice of local pressing, delaying the starting time of pressing to the greatest possible extent is effective in terms of attainment of higher adhesion strength. The local pressing method of the present invention, particularly the method in which bosses, ribs, and the like are pressed, allows delay in the starting time of pressing, thereby improving adhesion strength.

In molding of crystalline thermoplastic resins as employed in the embodiment, surface hardening starts at the respective solidification points of the resins, whereby the present method becomes more effective.

INDUSTRIAL APPLICABILITY

According to the present invention, portions at which the secondary resin molding product is united with the primary resin molding product with poor adhesion are pressed selectively and locally, whereby pressing can be effectively carried out.

Local pressing allows effective application of pressing to portions whose adhesion is to be improved, irrespective of surface hardening distribution of a molten resin at the time of filling a mold with the resin, whereby adhesion can be improved.

The present invention can provide a composite injection molding product in which adhesion and air tightness of the secondary resin molding product to the primary resin molding product are improved.